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SUBSTITUTE SPECIFICATION

TEMPERATURE COMPENSATED BANDGAP VOLTAGE REFERENCE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is based on and claims priority of U.S. provisional patent application Serial No. 60/441,063, filed January 17, 2003, entitled TEMPERATURE  
5 COMPENSATED BANDGAP VOLTAGE REFERENCE, the entire disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention is directed to a temperature compensated bandgap voltage reference.

10 Figure 1 shows how a reference voltage based upon  $V_{be}$  of a bipolar transistor can be obtained. The current source  $I$  is provided in the emitter path of a bipolar transistor. A plurality of current sources can be provided each coupled to an FET of varying size to provide current sources of different magnitude, e.g.,  $I$ ,  $10I$ , etc. as shown.

15  $V_{be}$  of a bipolar transistor decreases with increasing temperature in a well-known fashion. See Fig. 3. It is also known that a current mirror can be used to obtain a voltage representative of  $\Delta V_{be}$  i.e., the difference between the  $V_{be}$  of two bipolar transistors. Figure 2 shows such a current mirror circuit.  $\Delta V_{be}$  is equal to  $V_{be2}$  minus  $V_{be1}$  and  $\Delta V_{be}$  is equal to  $kt/q \ln NI/I$ .  $\Delta V_{be}$  depends upon the ratio of the  
20 currents of the current sources as well as the temperature. In particular,  $\Delta V_{be}$  increases with temperature. See Fig. 3. By combining the two circuits, it is possible to compensate  $V_{be}$  of a first transistor with  $\Delta V_{be}$  obtained via two other transistors Q1